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(56) Documents Cited
GB 2257498 A GB 1469182 A GB 1342093 A
GB 0916870 A US 4807795 A

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(54) Apparatus for explosive ordnance disposal

(57) An explosive assembly comprises a liner of combustible material eg. magnesium, of concave-convex cross-section (preferably generally L-shaped section) with a layer of explosive material secured to the convex surface of the liner. Use as a cutting charge for example to destroy munitions by cutting through the case and igniting the contents. The magnesium may be located on the back of a copper liner. Other suitable combustible materials includes Ti, Zr, Hf, Ce, La, Nd and Fe and alloys containing these metals.

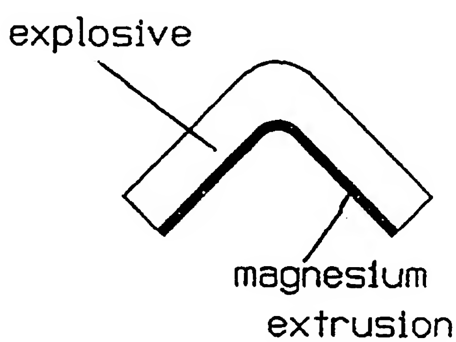

Fig. 4

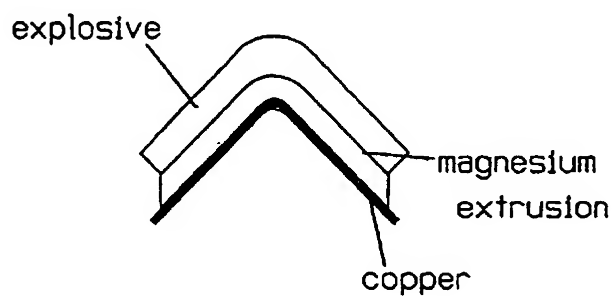

Fig. 6

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply

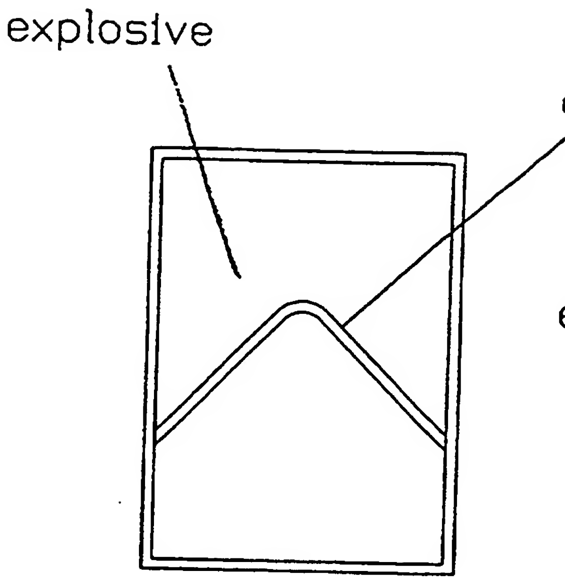

Fig. 1

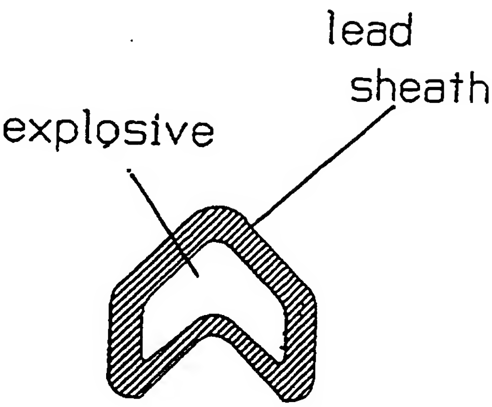

Fig. 2

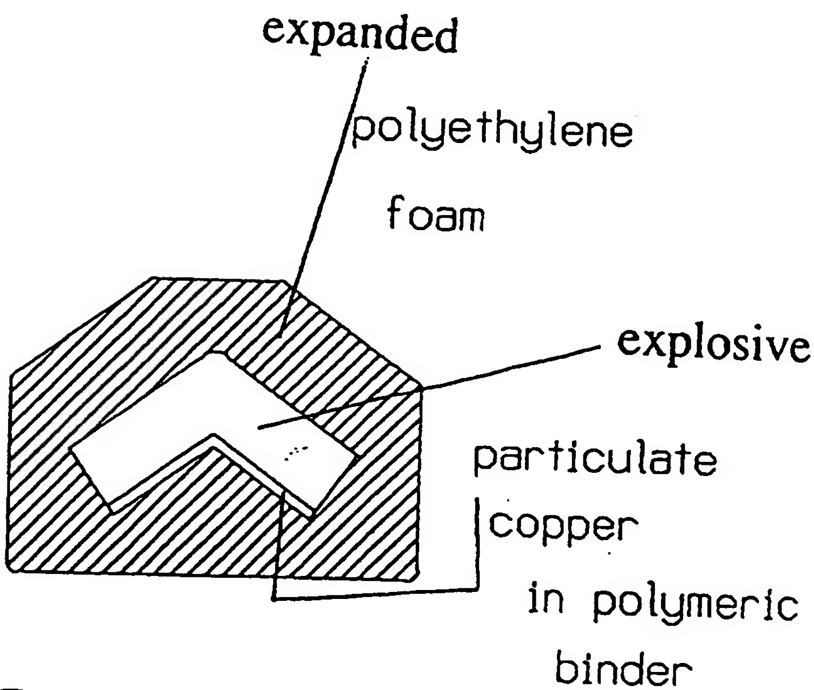

Fig. 3

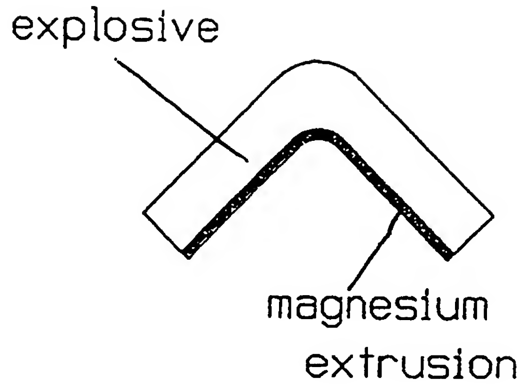

Fig. 4

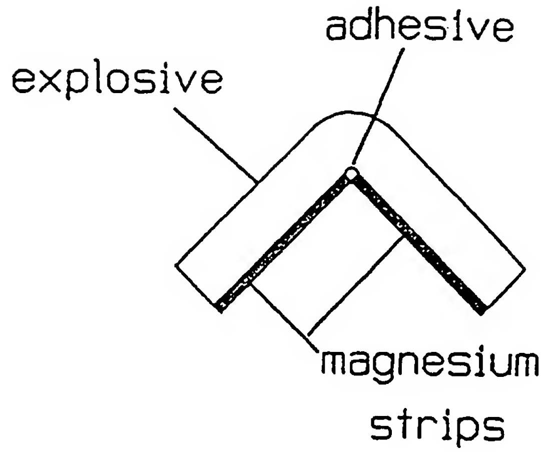

Fig. 5

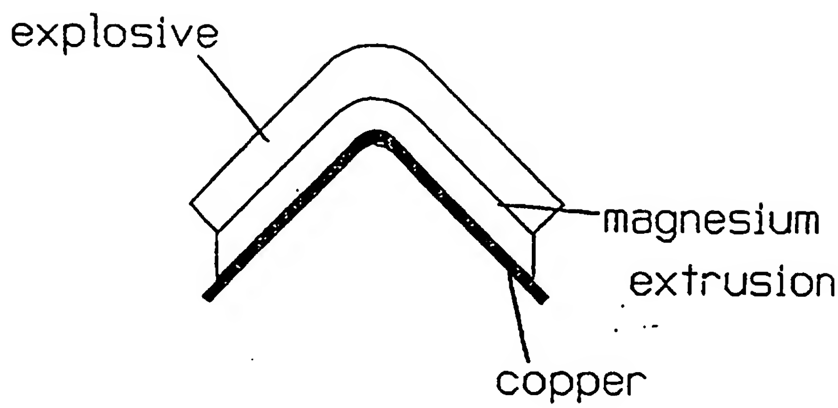

Fig. 6

Improved Apparatus for Explosive Ordnance Disposal

Conventional military explosive ammunition includes bombs, shells, land and sea-mines, torpedoes, and the warheads of rockets. These most commonly consist of generally cylindrical cases filled with high explosive and provided with one or more means of initiating the detonation of this explosive such as a fuse which is itself actuated by an external influence such as contact with, or proximity to, a target, or which is self-actuated with the passage of time. It is frequently required to destroy such munitions which have malfunctioned or, in the case of those incorporating a time-fuse, which have not yet functioned, or those which have not been deployed but which are surplus to requirement. With the exception of land-mines, which are frequently encased in plastics material, such ammunition is almost invariably metal cased. Whereas rocket warheads are often made in aluminium alloy for the sake of lightness, aircraft bombs, mortar bombs, shells and sea-mines are almost invariably fashioned in steel or cast iron. The thickness varies from typically 2.5mm in the case of the body of a 2 inch mortar bomb to more than 25mm along the body of a shell to be fired from a large calibre (for example 8 inch) gun. In such items as squash-head shells, the steel is necessarily strong and ductile: in the case of more modern mortar bombs and shells, the case may be relatively brittle in order to favour fragmentation.

If the ammunition is taken from stock to be destroyed it will usually not be equipped with a fuse. In the case of fused ammunition such as a large air-dropped bomb, shell, or sea-mine, it is often removed by explosive, mechanical or manual means before the rest of the item is destroyed.

The simplest method of destroying such munitions consists of placing a donor charge of explosive in contact with, or in close proximity to, the munition, and using the detonation of this donor charge to initiate sympathetic detonation of the target munition. A variant of this method is to use a radially symmetrical shaped charge, which projects a very high velocity jet of metal at the target munition, causing it to explode without needing to be handled.

The greatest disadvantage of this method is that it causes the munition to explode with its full violence, the operator having control only over the moment at which such explosion occurs. Any method which requires the placing of a donor charge in direct contact with the munition is also potentially hazardous in that it may be so fused, or so sensitized by damage or weathering, as to be dangerously sensitive even to slight disturbance.

Since it is frequently desirable to prevent the detonation of the item to be destroyed, in order to mitigate any damage caused to the environs, a frequently employed modification of this method consists of using a donor charge of such reduced size that it breaks open the case of the target munition without initiating detonation of the contents. The two main disadvantages of this method are, first, the uncertainty of achieving just the required degree of disruption, avoiding mere denting of the case and possible projection of the target munition on the one hand, and causing detonation on the other and, secondly, that the exposed but unconsumed explosive of the target munition still has to be destroyed. This secondary destruction may be accomplished by placing an incendiary charge in the open casing and burning out the explosive, but it is usually preferred not to have to approach a munition which has been once attacked by explosive means lest it be in a sensitized condition as a result of the first intervention, and also because multiple approaches are relatively time consuming. For example, a dormant fuse mechanism might have been activated, or a slow, unperceived combustion have been induced. It is therefore customary, when circumstances permit, to wait up to thirty minutes before returning to examine the munition between interventions.

A preferred method, well known to those skilled in the art, is to use an explosive linear cutting charge to produce a longitudinal or circumferential cut through the case of the target munition, and to project hot jet material into the explosive filling.

Such a charge consists of an elongate mass of explosive provided with a longitudinal angular or semi-cylindrical groove which is lined with metal. This metal component is known as the "liner". One known charge consists of an elongate cuboid metal case divided longitudinally by a strip of longitudinally angled copper (Fig 1). Explosive is filled on the convex side of the copper liner. Another known charge consists of a lead tube containing explosive with a longitudinal groove formed along one side (Fig 2). A variant, recently preferred for the purpose of destroying explosive munitions, consists of an elongate strip of explosive with an angular liner consisting of finely particulate copper embedded in a flexible matrix of inactive organic polymeric material (Fig.3).

If the metal jet produced by such charges is sufficiently well formed, directional and energetic, it will cut a slot through the case of the target munition. If the residual energy is sufficient, and an adequate amount of hot jet material is projected into the explosive filling, the latter will be ignited. If the residual energy is excessive, there is a danger that detonation will occur.

The preferred result of the operation is that the explosive content should ignite, and burn out completely and quietly through the cut in the case. If the cut does not provide sufficient venting, as may be the case if the cut is not long enough, or if the initial combustion of the fragmented explosive is too fast, internal pressure rise will occur. This, in turn, will lead to faster combustion. In this event, pressure may be relieved by dissension of the cut, but it is usual for the case to burst open violently, but without detonation: in a significant proportion of cases, however, pressure is not relieved quickly enough and detonation does occur.

If the target munitions are ignited without detonation occurring, any sudden bursting of the case causes an instantaneous drop in pressure, and the momentum of the escaping combustion products removes them from the burning surface, causing both adiabatic cooling and oxygen deprivation. When this occurs the combustion usually ceases, some unconsumed explosive remaining in the case, and other pieces being scattered about, and a second intervention for the purpose of re-ignition is necessitated.

Thus this method, though giving an ideal result when it works properly, is notoriously likely to require a time-consuming and potentially dangerous second intervention or to cause unintended detonation.

It is the purpose of the present invention to provide a means of perforating the case of ammunition, but with decreased probability of causing detonation, and increased probability of inducing successful ignition; it also decreases the probability of autoextinction in the event of violent bursting of the munition case.

It has been demonstrated that, if a shaped charge be provided with a liner of a metal able to undergo self-sustaining combustion in air, the jet usually ignites as it is formed. It follows that such a jet, if used to perforate the casing of an explosive-filled munition, will be burning even before it impinges on the target. This raises the jet to a very much higher temperature than that of a conventional copper jet, which, though hot enough to become discoloured as a result of superficial oxidation, does not melt. A liner of magnesium, for example, is injected as a brilliantly white-hot mass.

Thus a shaped charge with such a liner is a much more powerful initiator of combustion than is one lined with copper, lead, or any other such incombustible metal.

One embodiment of the invention consists of an extruded L-section of magnesium, having an angle of ninety degrees, with sheet explosive stuck to the convex surface so as to form a linear cutting charge (Fig 4). In another embodiment, such a right-angled liner is fabricated by supporting two flat strips of magnesium so that one long side of each is in contact with the other at the required angle (Fig 5). An angle of

ninety degrees is suitable for this invention, but the invention is not limited to liners of this angle.

The relatively low density of magnesium (1.74g/cm^3) compared with that of copper (8.95g/cm^3), which is a metal commonly used for linear cutting charges, causes it to be less penetrating than copper but it is nevertheless capable of producing well formed cuts. In a preferred embodiment of the invention a thin copper liner is provided with a layer of magnesium along its back, with the explosive applied to the back of the magnesium (Fig. 6). In a linear cutting charge assembly using a liner of copper alone, maximum efficiency, as measured by the depth of penetration of a target of given material as a function of the amount of explosive per unit length of the charge, is provided by a liner of a particular thickness. In a charge with a composite copper/magnesium structure, the thickness of the copper should be reduced, and the thickness of the magnesium so adjusted, that the resultant mass of metal per unit area remains approximately the same.

The invention may also be used for the ignition of non-explosive pyrotechnic flare and smoke compositions, as well as incendiary fillings of bombs and shells and the propellant charges of rockets and shells.

The application of 3mm thick magnesium to the back of 1.6mm copper liners, which, by themselves, with a given charge of explosive, penetrate 25mm steel plate, diminishes their penetration to an extent that they will no longer do so. Diminution of the thickness of the copper to 1mm restores the penetration. Such a liner, used with an explosive load of 633g/m of sheet explosive SX2, is more penetrating than would be a linear cutting charge with a flexible liner of particulate copper in a polymeric matrix with a similar explosive load.

Particles of magnesium projected through target plates into the hard earth beneath have continued to burn for about a minute. It is therefore most likely that the "snuffing out" of burning filling as a casing bursts violently would not be immediately followed by re-ignition.

By way of example

Example 1

A 3mm thick layer of explosive was stuck to the outside of a liner consisting a magnesium extrusion, with 16mm external sides, and 1.5mm thick, giving an explosive loading of 154g/m. This was spaced at a distance of 30mm from a 6mm thick mild steel plate. Upon detonation, the plate was severed.

Example 2

A 6mm thick layer of explosive was applied to a similar liner to that of Example 1, giving an explosive load of 308g/m. Upon detonation, the charge severed a mild steel plate 15mm thick at the same distance.

Example 3

Two strips of magnesium 22mm wide and 3mm thick were joined along one long edge to form a right-angled liner. A 3mm thick layer of explosive was applied to the convex surfaces by means of rubber cement giving an explosive load equivalent to 240g/m. The metal liner was spaced at a distance of 18mm from target plates of 43A grade mild steel. Upon detonation, the jet perforated a sheet of 6mm thick steel, and penetrated a thicker plate to a depth of 7mm.

Example 4

A similar magnesium liner to that of Example 3 was provided with a 6mm thick layer of explosive, giving an explosive load equivalent to 480g/m. The metal liner was spaced a distance of 18mm from a 10mm thick steel plate. Upon detonation a wide (11mm) cut was made through the plate, and burning magnesium passed through the target.

Example 5

A similar charge to that of Example 3 was spaced a distance of 73mm from a 10mm thick target. Upon detonation a very regular and narrow (5mm) cut was made through the target.

Example 6

A similar charge to that of Example 3 was provided with a 9mm layer of explosive, giving an explosive load equivalent to 720g/m. The metal liner was spaced a distance of 21mm from a 15mm thick steel plate. Upon detonation a clean cut was made through the target, but with considerable spalling of target metal. A large amount of magnesium continued to burn in the ground beyond the target plate.

A further series of examples, shown in tabular form, describes the penetration of charges lined with magnesium, copper, and a combination of both, when fired at plates of 43A grade steel. The magnesium consisted of 3mm and 5mm thick extruded right-angled section with 24mm sides.

When used together with copper, the latter was stuck with rubber-based contact cement to the inside of the magnesium.

Example No.	explosive (g/m)	Cu (mm)	Mg (mm)	liner wt. (g/cm^2)	stand-off (mm)	depth (mm)	severed (mm)
1	240	-	3	0.520	18	7	6
2	480	-	3	0.520	18	-	10
3	480	-	3	0.520	73	-	10
4	720	-	3	0.520	21	-	15
5	633	1.6	-	1.430	33	-	25
6	633	1.6	3	1.950	33	19	-
7	422	1.0	3	1.415	33	16	-
8/9	633	1.0	3	1.415	33	-	25 (twice)
10	633	-	6	1.045	33	3 ~ 4	-

Notes

The experiments so far conducted have employed magnesium as the combustible metal and copper as a relatively dense but non-combustible metal, but the invention is not limited to the use of these metals.

The liner material may consist of any metal, or alloy of metals, which is capable of sustaining combustion in air when not in a fine-divided form. Such materials include magnesium, titanium, zirconium, and hafnium as well as their alloys with aluminium, lithium, calcium or lead.

In a further embodiment of the invention the liner may consist of such metals as exhibit mechanically-induced pyrophoricity such as those commonly used as "flints" in lighters. These include cerium, lanthanum, neodynium and iron, alloys of any of these, and their alloys with tin or lead.

In yet another embodiment of the invention the liner may consist of compressed mixtures of such finely divided metals as react exothermically when raised to the melting point of one component. An example of such a mixture is that of nickel and aluminium in a ratio corresponding to the reaction: $Ni + 2Al \rightarrow Al_2Ni$.

In those embodiments of the invention in which a metal liner of relatively high density lines the inner surface of a composite liner, suitable materials are copper, steel and iron. Copper has the advantage of ductility, but steel and iron themselves undergo some combustion when used to line shaped charges and would therefore make a slight additional contribution to ignition.

In yet another embodiment of the invention, a flexible charge may be made by using plastic explosive and a lining of finely divided magnesium, or other easily ignited metal, in a flexible matrix of polymeric organic material, such as polyisobutylene or hydroxy-terminated polybutadiene. The penetration of such a liner may be enhanced by the incorporation of particulate metals of higher density than magnesium such as copper, lead, tungsten or iron.

It will be understood that the charge may be of any desired length, the length being chosen dependent on the length of cut which may be made in the case of an explosive charge which is to be destroyed.

CLAIMS

1. An explosive assembly comprising a liner comprising combustible material and of concave-convex cross section, with a layer of explosive material secured to the convex surface of the liner.

2. An assembly according to Claim 1 wherein the liner consists of two flat portions meeting at an apex.

3. An assembly according to Claim 2 wherein the liner is generally L-shaped.

4. An assembly according to any one of the preceding claims wherein the combustible material comprises magnesium.

5. An assembly according to any one of the preceding claims wherein the liner comprises a combustible material adjacent the explosive layer and a more dense less combustible material secured to the concave surface of the combustible material.

6. An assembly according to Claim 5 wherein the more dense material is copper.

7. A method of destroying an explosive charge by combustion comprising placing an explosive assembly according to any one of the preceding claims in proximity to the charge to be destroyed and detonating the explosive assembly.

The Patent Office

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Application No: GB 9424483.7
Claims searched: all

Examiner: R C Squire
Date of search: 18 December 1995

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.N): F3A

Int Cl (Ed.6): F42B; F42D

Other: Online:WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB2257498A	RHEINMETALL (see page 7 lines 6 to 12)	1,4,5
X	GB1469182	KNAPP (see page 2 lines 63 to 69)	1,4,5
X	GB1342093	METHIONICS (see page 8 line 87 to page 9 line 4)	1
X	GB916870	SCHLUMBERGER	1,5,6
X	US4807795	LAROCCA	1,4,5,6

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